

# What's Next for Puget Sound Science? Issues Identified Through Ambient Monitoring

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## Abstract

The Puget Sound Ambient Monitoring Program (PSAMP) is an interagency effort to assess the condition of Puget Sound and its resources. PSAMP's studies of the physical environment, pathogens and nutrients, toxic contaminants and biological resources are carried out by the Washington State departments of Ecology, Fish and Wildlife, Health and Natural Resources; the King County Department of Natural Resources, the National Marine Fisheries Service and the U.S. Fish and Wildlife Service. As they present PSAMP findings, the program's scientific investigators draw conclusions about environmental problems confronting the region and make recommendations for follow-up resource management actions and/or additional investigation. Through these conclusions and recommendations, the PSAMP helps to define next steps for and future needs from Puget Sound scientific inquiry addressing issues related to human alteration of Puget Sound's physical environment; pollution of Puget Sound by nutrients, pathogens and toxic contaminants; and the effects of these and other stresses on Puget Sound biological resources. PSAMP scientists and managers highlight specific findings (and interpretations) and critical data gaps to encourage the region's scientific community to more fully analyze these issues to improve the connections between monitoring, research and management of the Puget Sound ecosystem.

## Introduction

The Puget Sound Ambient Monitoring Program (PSAMP) was developed in the mid-1980s to provide comprehensive, long-term monitoring of Puget Sound and its resources. Since 1989, PSAMP has collected data on marine sediments; water quality in open marine waters, shellfish growing areas, and in large rivers; and biological resources, including benthic invertebrates, fish, birds and mammals and nearshore habitats. PSAMP is designed to complement existing monitoring programs to utilize the scientific capabilities of the various public agencies working on Puget Sound environmental and natural resource issues.

The program operates through the work of many agencies, including:

- Washington State Department of Ecology (Ecology)
- Washington State Department of Fish & Wildlife (Fish and Wildlife)
- Washington State Department of Health (Health)
- Washington State Department of Natural Resources (Natural Resources)
- King County Department of Natural Resources (KCDNR)
- U.S. Fish & Wildlife Service (US Fish and Wildlife)
- U.S. Environmental Protection Agency (EPA)
- National Marine Fisheries Service—Northwest Fisheries Science Center (NMFS)
- Puget Sound Water Quality Action Team (PSAT)

Following its conceptual model of the many varied effects of human actions on the Puget Sound marine environment (Newton and others 2000), PSAMP describes its investigations as addressing five topics as shown in Table 1. Additional information about PSAMP monitoring of each of these topics is provided in recent issues of the *Puget Sound Update* (PSAT 2000a; PSAT 1998).

Table 1: PSAMP Monitoring Topics

Monitoring Topic	Components Monitored	Implementing Agency
Physical Environment	Physical characteristics of open marine waters and rivers and streams	Ecology
	Physical characteristics of open marine waters	KCDNR
	Physical features of nearshore marine habitat (shallow subtidal, intertidal and adjacent shorelands)	Natural Resources
Pathogens and Nutrients	Fecal contamination, nutrients, dissolved oxygen in open marine waters and rivers and streams	Ecology
	Fecal contamination, nutrients, dissolved oxygen in open marine waters	KCDNR
	Fecal contamination in shellfish growing waters	Health
Toxic Contaminants	Contamination and toxicity of marine sediment	Ecology
	Contaminant and toxic effects in fish and mammals	Fish and Wildlife NMFS
	Contaminants in marine sediment, marine water, shellfish, algae	KCDNR
Human Health	Biotoxins and pathogens in shellfish	Health
	Contaminants in edible tissues of fish	Fish and Wildlife
Biological Resources	Benthic invertebrates	Ecology
	Nearshore vegetation	Natural Resources
	Marine birds, mammals and fish	Fish and Wildlife

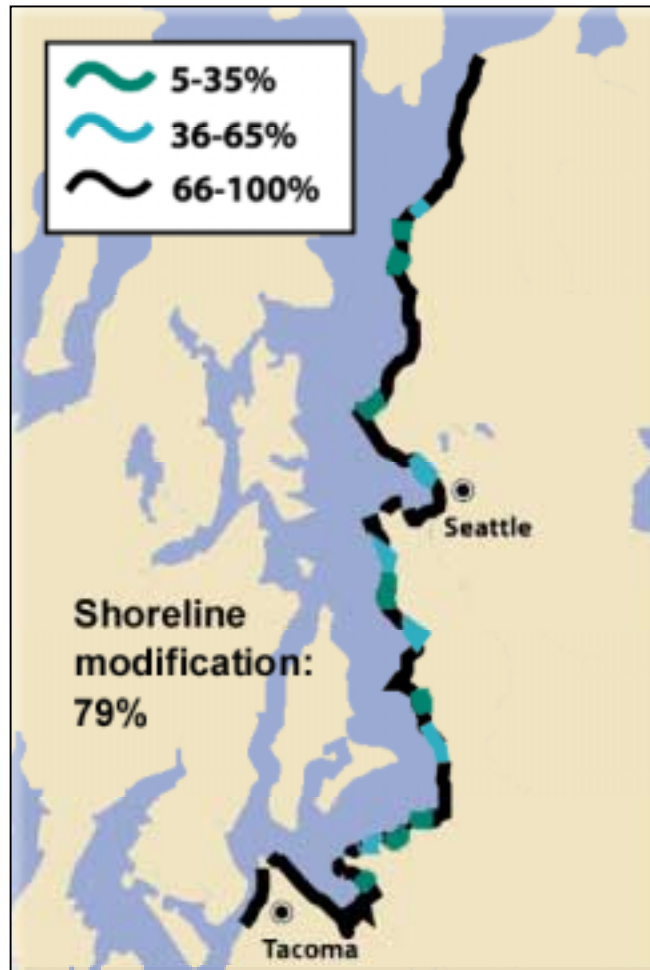
As a government-sponsored ambient monitoring program, it is important that PSAMP develop and maintains links to the scientific research community. These links ensure that the program's scientific investments are useful to others and also allow PSAMP to build upon improvements in monitoring and assessment methodologies and understanding of the Puget Sound ecosystem. To support research efforts, PSAMP (1) produces and disseminates scientifically valid data on environmental and ecological conditions in Puget Sound and (2) provides logistics support (e.g., sampling platforms) to enable data collection for research projects. Scientific research of Puget Sound environmental issues supports and complements PSAMP by (1) investigating causes of existing, emerging or anticipated environmental problems (e.g., investigations of the decline of the Cherry Point stock of Pacific herring) and (2) developing accurate, practical and cost-effective methods for monitoring (e.g., approaches to mapping and monitoring subtidal eelgrass).

## Issues Identified through Ambient Monitoring

The *2000 Puget Sound Update* (PSAT 2000a) summarizes the findings of PSAMP monitoring studies and other scientific investigations based on information available through mid-1999. In the course of compiling this report, Action Team support staff and PSAMP scientists and managers developed a number of recommendations for further scientific investigation (or for new or modified management responses). These recommendations, presented at the end of each chapter of the *Update*, are not comprehensive, nor are they presented in a manner that indicates their relative priority. In the sections that follow, I highlight an issue (or perhaps a pair of issues) from each PSAMP-monitoring topic to produce a short list of the research-relevant concerns that strike me as some of the most important outcomes of PSAMP in recent years. The sections below each provide a brief statement of a PSAMP finding and a short discussion of a related research issue. Please consult the *2000 Puget Sound Update* or the reports of the PSAMP studies for more information about the findings.

### Physical Environment

Natural Resources' ShoreZone inventory (Natural Resources 2001) characterizes the physical and biological condition of Washington's marine shoreline. This data set shows that approximately 80% of Puget Sound's eastern shoreline from Mukilteo to Tacoma has been modified by bulkheads, sea walls, rip rap and other modification of intertidal lands (Figure 1).



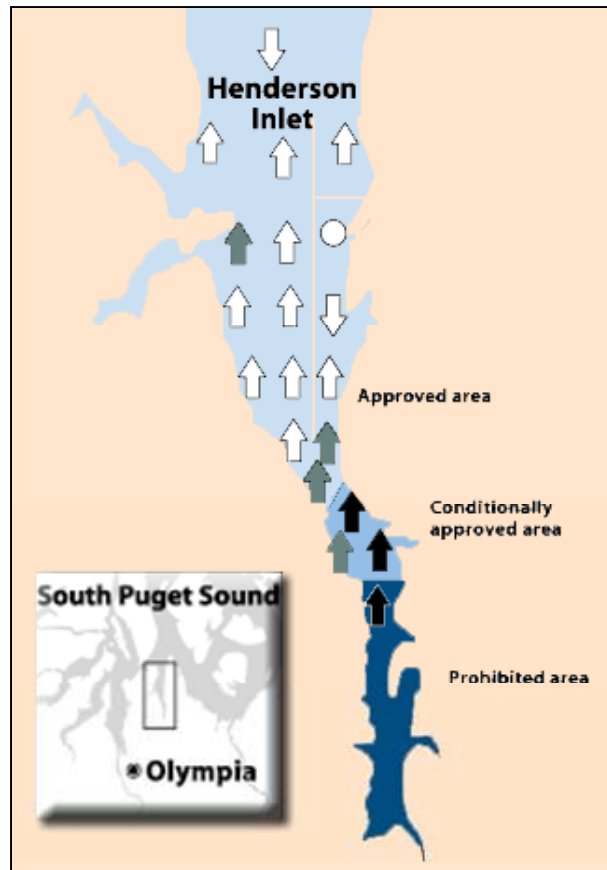
**Figure 1.** Shoreline alteration from Mukilteo to Tacoma from Natural Resources' ShoreZone Inventory (Natural Resources 2001).

This specific result, highlighted in the *2000 Puget Sound Update*, describes the extent of shoreline alteration in the most heavily affected portion of Puget Sound. Other data from the ShoreZone Inventory show the extent of alteration in other areas of the Sound.

The implications of existing and proposed future shoreline alteration for nearshore physical processes and biological functions are not well understood nor well communicated. While I believe we have firm conceptual understanding of potential impacts, I suggest we need better descriptions and predictions about the effects of specific alterations (existing or proposed) and better understanding of the cumulative effects of many relatively small alterations on shoreline physical processes (e.g., sediment routing and delivery) and biological resources (e.g., intertidal biota).

#### **Pathogens & Nutrients**

Department of Health analysis of water quality data from shellfish growing areas indicates that fecal contamination is worsening in some shellfish growing areas downstream of urbanizing watersheds. For example, fecal contamination is increasing at most monitoring stations in Henderson Inlet in south Puget Sound, near Olympia, Washington (Figure 2).



**Figure 2.** Trends from January 1998 to March 1999 in fecal contamination at individual stations monitored in Henderson Inlet by Department of Health. Arrows pointing upward indicate increasing concentrations. Arrows pointing downward indicate decreasing concentrations. A circle indicates “no trend” in concentrations. Black symbols indicate that growing area standards are not met at this station.

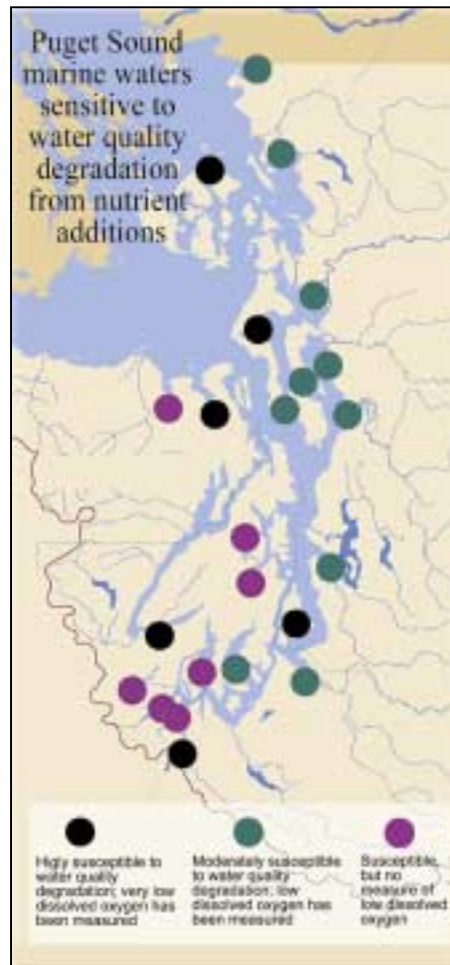
This finding suggests that there may be a level of watershed development above which water quality impairment precludes the safe harvest of shellfish. Scientific study of this hypothesis should be a priority focus of efforts to study relationships among land use, land management practices, and water quality. Findings from such studies must then be incorporated into watershed planning, land use planning and regulation, and best management practices to protect water quality in shellfish growing areas.

Department of Ecology monitoring of marine waters identified 23 of 43 monitored locations in Puget Sound as susceptible to nutrient-related water quality degradation. Dissolved oxygen (DO) below 2 mg/L has been measured at six locations; concentrations below 5 mg/L have been measured at another 10 locations. An additional 7 stations are thought to be sensitive to nutrient additions, though low DO has not been observed.

This finding indicates a need for additional investigation to address a few follow-on questions:

- What is the human contribution to low DO problems in Puget Sound?
- What is the “natural” pattern of low DO related oceanic input of nutrients to poorly circulating waters?

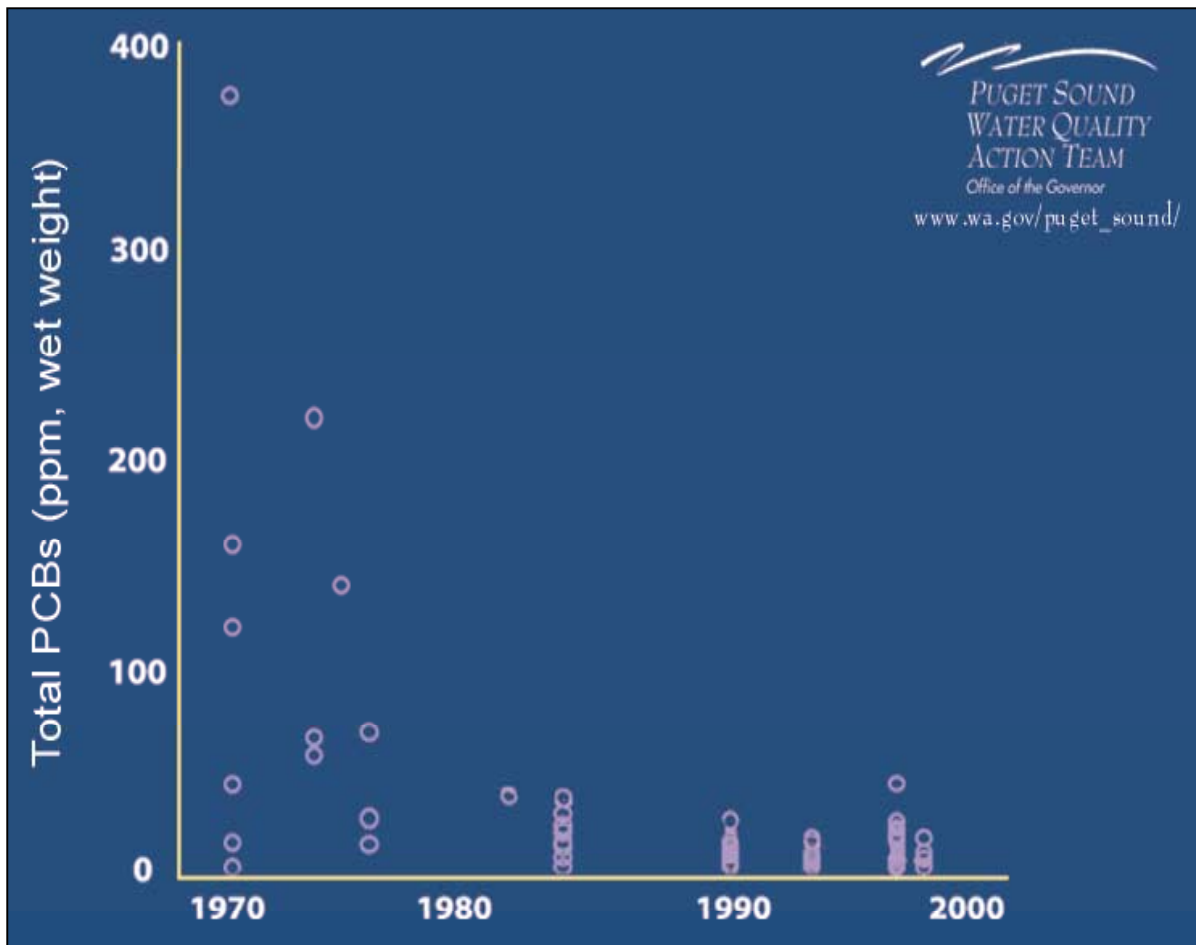
Answers to these questions can help design corrective management actions, if any are indicated.



**Figure 3.** Monitoring locations in Puget Sound with some indication of sensitivity to eutrophication based on measured low dissolved oxygen or susceptibility suggested by nutrient and hydrodynamic conditions. Unpublished analysis by Department of Ecology; previously presented in *Puget Sound's Health 2000* (PSAT 2000b).

### Toxic Contaminants

With the exception of data from the National Oceanic and Atmospheric Administration's Mussel Watch program, Puget Sound monitoring offers no evidence of declining toxic contaminant levels in marine organisms. For example, Calambokidis and others (1999) showed that PCB levels in harbor seals declined from the 1970s to the 1980s but suggests no declines since the 1980s (Figure 4).



**Figure 4.** Concentrations of PCBs in south Puget Sound harbor seals. (Calambokidis and others 2000)

This finding suggests a few follow-on questions:

- What are the dynamics of contamination in the Puget Sound ecosystem? Are present day loadings significant relative to contamination already in place in sediments and biota?
- Does the available evidence support decisions to step up efforts to control or remediate toxic contaminant problems?

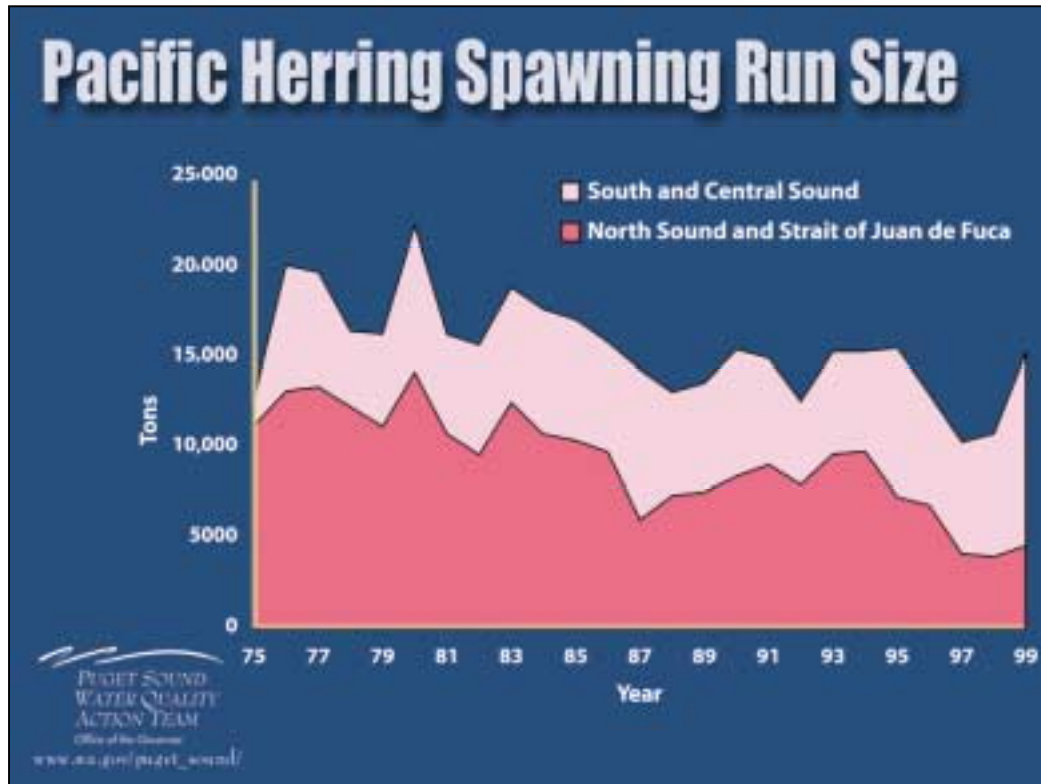
Answers to these questions will help the region's scientists and resource managers to design the management measures that will be most effective at decreasing the toxic contaminant burden experienced by a variety of marine organisms in Puget Sound.

### Human Health

Department of Health biotoxin monitoring has shown dramatically varying patterns (both geographically and temporally) of paralytic shellfish poison (PSP) toxins in shellfish in recent years. These variations are not clearly explained by any other covarying factors. Our poor understanding of the factors that determine PSP's distribution throughout Puget Sound means that we must simply react to blooms as they occur rather than being able to develop measures to attempt to control blooms. Continued study of PSP and other biotoxins is needed to help us answer questions such as "What are the human influences on the occurrence and distribution of PSP problems?"

### Biological Resources

Evidence from a number of sources shows that populations and stocks of a variety of marine organisms are in poor or declining condition (see PSAT (2000a) for more information). For example, Fish and Wildlife data show that spawning biomass of Pacific herring stocks in north Puget Sound and the Strait of Juan de Fuca has declined by about one-half from the levels seen in the 1970s.



**Figure 5.** Biomass of Pacific herring spawning in Puget Sound. (Unpublished data from Department of Fish and Wildlife.)

One issue raised by the multitude of concurrent declines is our relatively poor understanding of the trophic relationships among species. Relatively new analytical techniques (e.g., analysis of the ratios of stable isotopes, analysis of fatty acid signatures) might help us to describe trophic relationships and thereby contribute to our understanding of the food web influences in the declines of various species.

Better understanding of trophic relationships will be fundamental to a transition to an ecosystem-based approach to fisheries management.

### Other Issues

Data on the status of and trends in populations of primary producers and consumers in Puget Sound are sparse. Significant data gaps limit attempts at food web modeling. This, in turn, affects our ability to understand the transfer of toxic contaminants through the food web and causes of declines in stocks and populations of biological resources. Additional basic ecological research and monitoring of the base of the Puget Sound food web would greatly benefit our understanding of Puget Sound and our ability to manage resources from an ecosystem perspective.

Integration of information from various monitoring studies and other scientific investigations, including research studies, is needed to further understanding of the Puget Sound ecosystem. In particular we need to

support scientific analysis and synthesis that spans multiple trophic levels, levels of biological organization, and ecosystem stressors (e.g., toxics, physical alteration, trophic disturbance). This integration and synthesis will improve our ability to manage Puget Sound resources with an improved understanding of the ecosystem linkages among resources and between resources and stressors.

### Conclusions

This paper and the *2000 Puget Sound Update* provide a variety of findings that support recommendations for further scientific inquiry. This demonstrates that ambient monitoring works; information from PSAMP on status and trends of conditions in Puget Sound (1) informs us about problems, (2) suggests hypotheses for additional investigation and (3) identifies issues for management attention.

The examples of PSAMP findings and related recommendations presented here also suggest that ambient monitoring is insufficient. PSAMP's current scope and design do not complete the adaptive management feedback loop; additional scientific effort is often required to identify specific management responses needed to address PSAMP-identified problems.

### Acknowledgements

My sole authorship of this paper was a matter of convenience and is a poor reflection of the contributions from the scientists and managers who implement and oversee the Puget Sound Ambient Monitoring Program.

This paper grew out of my discussions with Tom Mumford, who suggested and chaired the session of the Puget Sound Research Conference where this material was presented, and out of my experiences over the past few years in coordinating PSAMP. The findings presented in this paper represent the work of PSAMP principal investigators, their staff and collaborators. I am especially indebted to Helen Berry, Tracy Collier, Jay Davis, Tim Determan, Maggie Dutch, Bill Ehinger, Steve Jeffries, Mary Mahaffy, Tom Mumford, Jan Newton, Sandie O'Neill, Dave Nysewander, Wayne Palsson, Randy Shuman, Kim Stark, and Jim West for freely sharing their findings and for working with me to communicate the findings of our interagency program.

The conclusions presented here are my own, though I hope they capture the sentiments of PSAMP's scientists and managers.

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